PRESSURIZER FOR A ROCKET ENGINE

REFERENCE TO RELATED APPLICATION

[0001] This application is a Continuation-in-Part (CIP) of U.S. application Ser. No. 10/214,706, entitled "Pressurizer For a Rocket Engine," filed Aug. 9, 2002.

BACKGROUND

[0002] Rocket engines require propellants to be fed to them at very high pressures. This has historically been accomplished in two general ways: first, with the use of a pressurized fluid, such as high pressure helium; and second, with the use of a pump.

[0003] In the first way (e.g., a "blowdown" system), a pressurized fluid, such as helium, is added directly to the propellant tank and exerts a force on the propellant. The problem with this method, however, is that the pressurized fluid also exerts a force on the propellant tank. Because of the extremely high pressures required of the pressurized fluid, the walls of the propellant tank must be thick enough to withstand the pressure. The propellant tank is therefore very heavy. Rockets employing the pressurized fluid must use a greater proportion of their thrust lifting this extra weight, and therefore they are not as efficient as rockets that do not require this added weight.

[0004] Historically, one way to solve the above weight problem is with the use of a pump. Pumps (e.g., reciprocating, centrifugal, or radial pumps) are generally very complex and expensive and require their own driving means, such as an engine. Further, the engine driving the pump burns a significant percentage of the total propellant. For small rocket engine systems, since a pump is too complicated and too expensive, pressurized fluids are generally used to pressurize the propellant. However, for large rocket engine systems, pumps have the advantage that the walls of the propellant tank need not be thick, since there is little pressure in the tank. Therefore, the propellant tank is much lighter, and the added weight of the pump is more than offset by the reduction in propellant tank weight.

[0005] U.S. Pat. No. 3,213,804 to Sobey ("Sobey") discloses fluid pressure accumulators that are connected to sources of low and high pressure by means of valves. Essentially, the pressurized fluid exerts force on the propellant in small, designated storage tanks. While the walls of these containers must be thick in order to withstand the high pressure of the pressurized fluid, the walls of the propellant tank need not be. Therefore, the total weight of the rocket engine system employing Sobey's invention may be less than that of the previously discussed rocket engine system because these storage tanks (fluid pressure accumulators) are small in comparison to the propellant tanks.

[0006] U.S. Pat. No. 6,314,978 to Lanning, et al. ("Lanning") discloses a reciprocating feed system for fluids having storage tanks 1, 2, 3 that are similar in purpose to the fluid pressure accumulators disclosed in Sobey. Instead of valves 50, 52, 54 disclosed in Sobey, Lanning discloses four valves for each storage tank 1, 2, 3. For example, associated with storage tank 1 are: valve 13 between storage tank 1 and low pressure fluid 5; valve 16 between storage tank 1 and high pressure discharge 7; valve 20 between storage tank 1 and vent manifold 18; and valve 24 between storage tank 1 and pressurized gas supply 8. Each valve must be accurately and reliably controlled by a controller 11. Further, each valve may have an associated sensor 11*a*.

SUMMARY OF THE INVENTION

[0007] There are several problems with the Sobey and Lanning inventions. In order to reduce the weight of Sobey's (or Lanning's) device further, the sizes of the storage tanks must decrease (thus reducing their weight). However, as they decrease, both the system cycle time (the time to fully complete a filling and draining cycle of a storage tank) and the opening and closing time of the valves must decrease in order to accommodate the same propellant flow rate to the rocket engine. The system cycle time is limited both by the opening and closing time of the valves, as well as the time required to depressurize each of the storage tanks of high pressure pressurant before introducing the low-pressure propellant (otherwise, the high-pressure pressurant will push the low-pressure propellants in a undesirable backflow). Lanning discloses an achievable cycle time of around 4.5 seconds. However, neither Sobey nor Lanning addresses or discloses an apparatus or method for decreasing cycle time—and thus the mass of the system—by decreasing the opening and closing time of the valves or the time required to depressurize each of the storage tanks. The present invention aims to solve these and other problems.

[0008] In a preferred embodiment, the present invention provides for a pressurizer for pressurizing a fluid, comprising: at least two storage tanks, wherein, for each storage tank, said pressurizer may further comprise: a propellant entrance valve connected to and associated with said storage tank; a propellant exit valve connected to and associated with said storage tank; a pressurant entrance valve connected to and associated with said storage tank; and a pressurant exit valve connected to and associated with said storage tank, wherein each of said storage tanks is configured to be filled with said fluid under a low pressure when its associated propellant entrance and pressurant exit valves are open and its associated propellant exit and pressurant entrance valves are closed, and to be drained of said fluid under a high pressure by the force of a pressurant when its associated propellant entrance and pressurant exit valves are closed and its associated propellant exit and pressurant entrance valves are open, wherein, for each storage tank, its associated valves are configured to be opened and closed in a cycle to sequentially fill and drain their associated storage tank of said fluid, said cycle having a cycle time, wherein said cycles of said associated valves of said storage tanks are out of phase with each other such that at some time in which one storage tank is being filled with said fluid, at least one other storage tank is being drained of said fluid, and wherein said cycle time for each storage tank is between 1 and 500 milliseconds. In another aspect, the cycle time may be between 1 and 250 milliseconds, or between 1 and 100 milliseconds.

[0009] In another preferred aspect, each of said associated valves of each of said storage tanks may have an open time, which is the time required for the valve to move from a fully closed position to a fully open position, and a close time, which is the time required for the valve to move from a fully open position to a fully closed position, wherein, for each storage tank and its associated valves, a sum of the following terms may be less than 100 milliseconds: a) a maximum of